

Food Requirements of Pregnancy in Swine

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UNIVERSITY OF ILLINOIS
AGRICULTURAL EXPERIMENT STATION
BULLETIN 375

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7334:31-1.7376

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417383

Food Requirements of Pregnancy in Swine

H. H. MITCHELL, W. E. CARROLL, T. S. HAMILTON, and G. E. HUNT*

IN THE COURSE of his fundamental investigations of the nutrient requirements for milk production, Haecker^{4*} proceeded on the basis of the theorem that "in order to determine the actual net nutrients required to produce a given animal product, the composition of the product should be known Before a builder bids on a contract, he determines the quantity needed of each of the materials that are to appear in the structure. Without such specifications he would not know how much of each of the different materials would have to be provided." The statement implies, of course, that due recognition must be given to the possible transformation of nutrients in animal metabolism. With this thought in mind Haecker based his well-known feeding standards for milk production upon the composition of milk of different degrees of richness, and all American feeding standards for milk production have developed along the line initiated by Haecker.

The conception that the composition of the product formed by an animal, whether it be milk, animal tissue, or egg, determines the nutrient requirements for its formation, tho fundamentally sound, has not been extensively used in the formation of feeding standards other than those for milk production. Armsby's standards for the requirements of net energy embody the same principle, altho his protein standards are based upon less certain grounds. The principle has recently been applied by one of the authors^{11*} of this bulletin to the general field of the protein requirements of cattle, while the case of pregnant swine is considered on the same basis in the experiment reported herein.

No accurate and satisfactory estimate of the nutrients required by the pregnant female in the development of her young *in utero* can be made until the growth of the fetus and of the maternal nourishing and protective tissues has been measured and studied. The nutrients deposited in the uterus during pregnancy represent in the strictest sense of the term the nutrient requirements of pregnancy. Obviously the intake of digestible nutrients must exceed these requirements, since the animal body does not utilize its digested food in anabolism to the extent of 100 percent; however, the excess of digestible nutrients needed will depend upon the percentage utilization of the protein,

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energy, minerals, etc., contained in the food and will vary with the nature of the diet. Hence the nutrients required for pregnancy cannot be expressed satisfactorily in terms of digestible food nutrients. If the condition of pregnancy influences the metabolism of the maternal organism in such a way as to modify its requirements for nutrients, this influence must of course be considered in computing the food requirements of pregnancy.

PLAN OF THE EXPERIMENT

The purpose of the experiment was (1) to make a physical and chemical examination of the uterus and contents of gilts killed at different stages of gestation; and (2) to determine the nitrogen, calcium, and phosphorus balances of gilts during the entire period of gestation.

Sixteen gilts were used in the experiment, 9 of the Poland China breed, 6 of the Duroc-Jersey breed, and 1 of the Hampshire breed. They were all bred to the same Poland China boar. Five of the gilts were kept at the nutrition laboratory and were confined in metabolism crates continuously for 16 weeks in the case of 3 gilts, 15 weeks in one case, and 14 weeks in another. The remaining 11 gilts were kept at the swine barn and were fed as a single lot.

All gilts were fed a ration consisting of 86 percent cracked corn, 6 percent alfalfa meal, 4 percent tankage, 3 percent linseed meal, and 1 percent ground limestone. This ration was found to contain by actual analysis 16.87 percent moisture, 10.94 percent crude protein, 3.13 percent ether extract, 3.51 percent crude fiber, 3.22 percent ash, 62.33 percent nitrogen-free extract, .608 percent calcium, .360 percent phosphorus, and .0241 percent iron. Its gross energy content was equivalent to 3.61 calories per gram.

At the end of the fifth week of gestation the first gilt was sacrificed for examination, and at the termination of each of the subsequent weeks of gestation, up to and including the eleventh week, one gilt was slaughtered. Two gilts were slaughtered at the end of 12 weeks of gestation, one at the end of 13 weeks, two at the end of 14 weeks, one at the end of 15 weeks, and three at the end of 16 weeks.

At slaughter the uterus and contents only were removed for examination. Each uterus was opened and dissected into fetuses, membranes, amniotic fluids, and uterus, constituting five samples for chemical analysis. Individual weights were taken on each fetus and its respective membranes and fluids, and the crown-to-rump measurement on each fetus was taken with a caliper. Partially absorbed fetuses were weighed but not added to any of the chemical samples.

Where grinding of the samples was necessary, a phosphor-bronze power meat chopper was used to avoid contamination with iron.

Each chemical sample was analyzed for dry matter, nitrogen, ether extract, ash, iron, calcium, and phosphorus, and its gross energy was determined in the bomb calorimeter. The dry matter was determined by heating for 5 hours in an electric oven maintained at 105° C. The Kjeldahl method, with mercury and potassium sulfate additions previous to digestion, was used in the determination of nitrogen, the ammonia formed being distilled into approximately 4 percent boric acid solution, and titrated with standard sulfuric acid with a normality of either $\frac{N}{7}$ or $\frac{N}{14}$, using brom-phenol-blue as an indicator. The samples were ashed in an electric furnace with a pyrometer attachment at temperatures of about 600° C. For materials difficult to ash at this temperature the carbon residue after treatment with HCl was filtered off and burned separately. The ether soluble material was extracted in Soxhlet extractors for 48 hours. The calcium was determined by a modification of the McCrudden method,^{9*} the phosphorus by the Pemberton-Kilgore volumetric method,^{5*} and the iron by a modified Kennedy method.^{7*}

EXPERIMENTAL RESULTS

The gilts were bred in January or February, 1928, and approximately half of them were rebred before evidence of successful fertilization was obtained.

Gains in Body Weight

The gilts kept in outdoor lots had an average initial weight of 273 pounds and were hand-fed to gain approximately one pound daily. The average daily gain for the group, depleted from time to time as animals were removed for slaughter, was 1.05 pounds, and the average daily food consumption equaled 7.91 pounds.

The five gilts confined in metabolism cages in the nutrition laboratory, weighing initially from 235 to 295 pounds, were started on a daily intake of 6 pounds of feed per head, but their gains were so rapid that on February 16 the daily allowance was reduced to 5 pounds, which was readily cleaned up at all times. The average daily gains of these gilts from date of last mating to slaughter ranged from 1.04 to 1.27 pounds, the mean being 1.11 pounds. The much greater economy of gains in these confined gilts than in the group-fed gilts must have been the result of close confinement and possibly, to some extent, of a higher environmental temperature.

Digestibility and Metabolizable Energy of Ration

During the latter part of January, while each of the gilts in the metabolism crates was consuming 6 pounds of ration daily, a digestion trial lasting 7 days was undertaken. The coefficients of digestion obtained are summarized in Table 1. Only four of the gilts were included in this trial, since one of the five originally put in the crates had just been replaced by another gilt, because of failure to become pregnant.

TABLE 1.—SUMMARY OF DIGESTION COEFFICIENTS

Gilt No.	Dry substance	Crude protein	N-free extract	Crude fiber	Ether extract
	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
24 PC.....	81.5	71.3	89.1	33.2	64.7
69-33 DJ.....	84.4	75.7	90.5	39.7	72.9
66 PC.....	84.3	76.7	91.1	39.9	59.8
39-90 PC.....	81.1	69.3	88.7	33.5	68.8
Average.....	82.8	73.2	89.8	36.6	66.5

The dry matter of the ration showed an average digestibility of 82.8 percent, the crude protein 73.2 percent, the crude fiber 36.6 percent, the nitrogen-free extract (mainly starch) 89.8 percent, and the ether extract (mainly fat) 66.5 percent.

The gross energy of the feed and of the liquid and solid excreta was determined on composite samples from this digestion trial by means of the bomb calorimeter. The information obtained with reference to energy utilization is summarized in Table 2. The energy content of the urine as observed has been increased to that which would have been obtained if all the food protein had been catabolized. This has been done by adding to the observed daily energy content of the urine, 7.45 calories for each gram of nitrogen stored daily in the body.

Of the gross energy consumed 19.1 percent, on an average, was lost in the feces and 3.5 percent in the urine, leaving 77.4 percent to be metabolized in the body.

Weights of Uteri and Contents at Different Stages of Gestation

The gilts were slaughtered, either singly or in groups of two or three, at times ranging from 5 to 16 weeks after successful mating, the latter interval corresponding to the total length of gestation minus 2 or 3 days.

The measurements taken on each uterus and its various contents are assembled in Table 3. On the last two gilts, slaughtered at the end of the sixteenth week of pregnancy, the weights of livers and spleens were taken for each fetus and these organs were then com-

TABLE 2.—UTILIZATION OF ENERGY OF RATION

Gilt No.	Dry matter eaten per day and head	Energy per kilogram of dry matter				Percentage losses		Percentage metabolizable
		Total	Losses		Metabolizable	In feces	In urine	
			In feces	In urine				
	<i>kgs.</i>	<i>therms</i>	<i>therms</i>	<i>therms</i>	<i>therms</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
24 PC.....	2.263	4.337	.890	.151	3.296	20.5	3.5	76.0
69-33 DJ.....	2.263	4.337	.749	.160	3.428	17.3	3.7	79.0
66 PC.....	2.263	4.337	.764	.158	3.415	17.6	3.6	78.7
39-90 PC.....	2.263	4.337	.908	.140	3.289	20.9	3.2	75.8
Average.....	.....	.....	.....	.....	3.357	19.1	3.5	77.4

TABLE 3.—SEX, LENGTHS, AND WEIGHTS OF FETUSES, AND WEIGHTS OF MEMBRANES AND LIQUIDS
(All weights expressed in grams; lengths in centimeters)

Gilt 13 PC—5th week of gestation												
	Right horn of uterus				Left horn of uterus					Total	Average	
	?	?	?	?	?	?	?	?	?			
Fetuses, sex.....	?	?	?	?	?	?	?	?	?	?	9	...
Length.....	3.7	3.5	3.5	3.7	3.5	3.6	3.4	3.7	3.5	32.1	3.6	
Weight.....	4.55	3.98	3.90	4.69	4.26	4.82	4.24	5.13	4.59	40.16	4.46	
Membranes.....	43	46	45	41	38	53	43	48	34	391	43	
Liquids.....	113	112	114	93	52	167	187	69	75	982	109	

Gilt 99 PC—6th week of gestation												
	Right horn of uterus				Left horn of uterus				Total	Average		
	f	m	f	m	m	m	f	m				
Fetuses, sex.....	f	m	f	m	m	m	f	m	7	42.6	6.1	
Length.....	5.5	6.4	6.2	6.4	6.1	6.2	5.8	6.2	110.46	15.78		
Weight.....	12.19	16.97	15.84	17.32	16.80	16.15	15.19	92	801	114		
Membranes.....	55	132	126	140	122	134	87	66	414	59		
Liquids.....	31	51	68	50	61	87	66	66	414	59		

Gilt 26-39 DJ—7th week of gestation ²												
	m	m	f	m	f	f	m	f	m	f	Total	Average
Fetuses, sex.....	m	m	f	m	f	f	m	f	m	f	10	...
Length.....	9.0	8.9	8.9	7.5	8.7	8.8	9.2	9.1	9.0	8.6	88.1	8.8
Weight.....	37.80	38.21	35.25	33.56	35.12	35.62	40.14	38.14	38.41	34.21	366.46	36.65
Membranes.....	144	174	135	90	130	142	161	163	147	123	1 407	141
Liquids.....	111	101	120	99	89	111	79	90	113	59	972	97

Gilt 67-90 PC—8th week of gestation												
	Right horn of uterus				Left horn of uterus				Total	Average		
	f	f	m	m	m	m	m	m				
Fetuses, sex.....	f	f	m	m	m	m	m	m	6	70.0	11.7	
Length.....	11.7	11.5	11.7	12.0	11.6	11.5	11.6	11.5	72.02	498.27	83.05	
Weight.....	84.29	81.63	83.46	91.54	85.33	85.33	85.33	72.02	72.02	1 450	242	
Membranes.....	206	253	228	291	305	305	305	167	167	1 323	221	
Liquids.....	160	320	272	270	246	246	246	55	55	1 323	221	

TABLE 3.—Continued

Gilt 3-90 PC—9th week of gestation													
	Right horn of uterus				Left horn of uterus				Total	Average			
	f	m	f	m	f	...	f	m					
Fetuses, sex.....										7			
Length.....	14.3	14.0	14.5	14.4	15.0	.....	15.3	14.8		102.3		14.6	
Weight.....	151.2	147.3	159.6	159.8	161.0	.....	166.3	162.4		1 107.6		158.2	
Membranes.....	355	307	430	342	410	.....	428	427		2 699		386	
Liquids.....	1 041	378	723	602	381	.....	331	554		4 010		573	

Gilt 24-90 PC—10th week of gestation													
	Right horn of uterus				Left horn of uterus				Total	Average			
	m	f	.....⁴	m	f	m	.....⁵	m					
Fetuses, sex.....										5			
Length.....	17.1	17.3	.....	17.3	16.2	17.5	.....	.....		85.4		17.1	
Weight.....	256	246	.....	267	191	354	.....	.....		1 314		263	
Membranes.....	428	343	.....	524	232	418	.....	.....		1 945		389	
Liquids.....	521	322	.....	129	182	157	.....	.....		1 311		262	

Gilt 65-90 H—11th week of gestation														
	Right horn of uterus				Left horn of uterus								Total	Average
	m	f	m	m	m	f	m	f	f	f	f	m		
Fetuses, sex.....														
Length.....	20.0	19.8	20.5	20.1	19.3	18.8	20.2	17.7	18.3	19.7	19.3	19.8	12	.....
Weight.....	412	427	452	451	342	352	427	285	336	388	367	419	4 233.5	19.5
Membranes.....	347	335	330	532	277	305	310	417	229	445	402	316	4 658	388
Liquids.....	1 107	445	589	512	392	492	372	812	280	732	867	1 174	4 245	354
													7 774	648

Gilt 32 DJ—12th week of gestation															
	Right horn of uterus						Left horn of uterus						Total	Average	
	f	m	m	m	m	m	m	f	f	m ⁶ ⁶			f	m
Fetuses, sex.....															
Length.....	21.2	19.8	18.8	20.8	18.0	21.0	20.2	18.6	21.2	19.7	.....	.....	21.1	22.1	12
Weight.....	476	450	343	516	297	535	428	346	475	431	.....	.....	500	572	242.5
Membranes.....	235	211	126	352	152	213	187	153	345	170	.....	.....	241	405	5 369
Liquids.....	250	260	359	272	492	444	460	244	256	212	.....	.....	216	632	2 790
															4 097
															341

(Table is continued on next page.)

TABLE 3.—Continued

Gilt 69-30 DJ—12th week of gestation												
	Right horn of uterus						Left horn of uterus				Total	Average
	m	m	m	.....⁷	f	f	f	m	f	f		
Fetuses, sex.....	m	m	m	.....⁷	f	f	f	m	f	f	9	.....
Length.....	20.9	19.3	19.6	.....	19.7	18.8	19.9	21.1	21.3	20.2	180.8	20.1
Weight.....	512	372	456	.....	421	396	477	548	526	437	4 145	461
Membranes.....	274	142	172	.....	232	347	127	368	262	215	2 139	238
Liquids.....	198	193	141	.....	185	83	18	192	242	971 ⁸	2 223	247

Gilt 13-99 DJ—13th week of gestation														
	Right horn of uterus						Left horn of uterus				Total	Average		
	m	f	.....⁹	f	f	m	m	f	f	f			m	
Fetuses, sex.....	m	f	.....⁹	f	f	m	m	f	f	f	m	11		
Length.....	21.9	22.2	.....	21.7	19.7	21.5	20.5	22.4	21.3	22.4	23.2	22.8	239.6	21.8
Weight.....	502	589	.....	504	428	560	502	607	563	616	636	626	6 133	558
Membranes.....	102	149	.....	123	119	165	172	178	160	246	196	144	1 754	159
Liquids.....	189	344	.....	140	117	99	217	126	166	197	178	264	2 037	185

Gilt 69-33 DJ—14th week of gestation												
	Right horn of uterus					Left horn of uterus					Total	Average
	m	f	m	f	f	f	f	m	f	m		
Fetuses, sex.....	m	f	m	f	f	f	f	m	f	m	10	.....
Length.....	27.1	25.8	25.3	27.3	27.0	25.7	27.8	28.5	28.0	27.5	270.0	27.0
Weight.....	1 058	921	847	1 077	1 113	1 032	1 047	1 179	1 053	1 089	10 416	1 042
Membranes.....	395	242	295	487	256	322	332	436	314	375	3 454	345
Liquids.....	296	207	594	377	207	203	146	372	423	275	3 100	310

Gilt 24-9 PC—14th week of gestation												
	Right horn of uterus					Left horn of uterus				Total	Average	
	m	m	.....¹⁰	f	.....¹¹	f	m	m	f		
Fetuses, sex.....	m	m	.....¹⁰	f	.....¹¹	f	m	m	f	7	.....
Length.....	26.2	26.6	.....	27.3	.....	26.6	27.1	27.1	26.3	187.2	26.7
Weight.....	1 017	1 067	.....	1 018	.....	1 031	1 128	1 118	965	7 344	1 049
Membranes.....	282	397	.....	214	.....	308	349	460	562	2 572	367
Liquids.....	180	395	.....	287	.....	196	378	350	372	2 158	308

TABLE 3.—*Concluded*

Gilt 14-90 DJ—15th week of gestation ¹¹											
Fetuses, sex.....	Right horn of uterus					Left horn of uterus				Total	Average
	f	m	m	f	f	f	f	f	f		
Length.....	29.6	28.0	27.5	27.4	27.9	27.5	29.5	28.3	27.8	9	28.2
Weight.....	1 345	1 177	1 088	1 062	1 119	1 249	1 254	1 177	967	10 438	1 160
Membranes.....	338	323	299	272	188	419	334	252	212	2 637	293
Liquids.....	355	222	282	167	142	220	169	202	307	2 066	230

Gilt 24 PC—16th week of gestation											
Fetuses, sex.....	Right horn of uterus				Left horn of uterus				Total	Average	
	f	m	f	f	f	m	m	m			
Length.....	27.8	29.5	29.7	30.0	29.0	29.5	29.5	29.5	6	175.5	29.3
Weight.....	1 395	1 607	1 584	1 509	1 527	1 588	1 422	1 422	9 210	1 535	374
Membranes.....	385	452	339	279	368	422	374	348	2 245	374	186
Liquids.....	224	239	85	156	65	348	117	117	1 117	186	186

Gilt 39-90 PC—16th week of gestation												
Fetuses, sex.....	Right horn of uterus					Left horn of uterus					Total	Average
	f	f	m	f	m	f	m	f	m	m		
Length.....	26.2	25.2	27.6	28.8	26.4	28.1	28.5	29.8	27.5	30.2	10	27.8
Weight.....	942	854	1 140	1 262	973	1 194	1 277	1 278	1 125	1 360	11 405	1 141
Membranes.....	223	122	313	215	264	229	311	333	256	354	2 620	262
Liquids.....	112	158	178	111	154	190	113	136	122	162	1 436	144
Liver.....	21.0	23.7	34.2	39.9	31.2	33.0	41.4	40.6	37.6	44.8	347.4	34.7
Spleen.....	.4	1.9	1.7	1.4	2.1	1.4	1.3	2.5	1.5	1.8	16.0	1.6

Gilt 66 PC—16th week of gestation											
Fetuses, sex.....	Right horn of uterus			Left horn of uterus				Total	Average		
	m	f	m	f	m	f	f				
Length.....	29.0	28.3	27.5	27.4	27.5	28.7	25.7	7	1 941	27.7	
Weight.....	1 386	1 324	1 215	1 236	1 258	1 285	937	8 641	1 234	234	
Membranes.....	232	368	173	263	228	232	245	1 741	249	249	
Liquids.....	94	320	176	307	437	275	72	1 681	240	240	
Liver.....	52	34	47	44	43	39	32	291	41.6	41.6	
Spleen.....	2.0	2.2	2.2	1.8	1.8	2.4	1.7	14.1	14.1	2.02	

¹Sex doubtful at this age. ²With this gilt, the first one slaughtered, no attempt was made to distinguish the two horns of the uterus. ³Degenerate fetus: weight 58 gm., length 9.9 cm., sex male (?). ⁴Degenerate fetus: weight 20 gm. ⁵Degenerate fetus: weight 4.5 gm. ⁶Two degenerate fetuses: weight 133 gm. ⁷Degenerate fetus: weight 108 gm. ⁸During slaughter the uterus was accidentally cut open, setting free two pigs the positions of which identified them as the two fetuses nearest the fork of the uterus. The large amount of liquid weighed here partly belongs to these two fetuses and also to some ruptured sacs of others. ⁹Degenerate fetus: weight 144 gm. ¹⁰Degenerate fetus: weight 248 gm. ¹¹Degenerate fetus: weight 228 gm. ¹²During slaughter the right and left sides of the uterus were not sufficiently well marked to be certain which was which.

TABLE 4.—SUMMARY OF DATA ON SLAUGHTERED GILTS

Gilt No.	Week of pregnancy	Date slaughtered 1928	Live weight	Uterus and contents		Number of fetuses	Weight of—					
				Weight	Per-centage of body weight		Fetuses	Mem-branes	Liquids	Empty uterus	Right ovary	Left ovary
			<i>kgs.</i>	<i>gms.</i>	<i>percl.</i>		<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>
13 PC.....	5	March 23	151.9	2 489	1.6	9	40.2	391	982	861	5.8	7.2
99 PC.....	6	March 16	186.0	2 949	1.6	7	110.5	801	414	1 288	10	13
26-39 DJ.....	7	March 14	124.7	4 290	3.4	10	366.5	1 407	972	1 375	15 ¹	....
67-90 PC.....	8	March 15	142.0	4 953	3.5	6	498.3	1 450	1 323	1 328	12.5	9
3-90 PC.....	9	March 19	147.4	9 909	6.7	7	1 108	2 699	4 010	1 683	7	8
24-90 PC.....	10	April 5	164.6	6 645	4.0	5	1 314	1 945	1 311	1 811	9.5	9.2
65-90 H.....	11	May 29	206.4	21 372	10.3	12	4 658	4 245	7 774	3 179	10	26 ²
32 DJ.....	12	April 16	206.4	15 334	7.4	12	5 369	2 790	4 097	2 425	7.6	11.3
69-30 DJ.....	12	April 18	206.4	11 326	5.5	9	4 145	2 139	2 223	2 133	6.6	7.2
13-99 DJ.....	13	April 30	165.5	12 702	7.7	11	6 133	1 754	2 037	2 124	5.2	10.2
69-33 DJ.....	14	May 7	196.4	21 159	10.8	10	10 416	3 454	3 100	3 375	8.0	6.4
24-9 PC.....	14	May 31	183.7	15 663	8.5	7	7 344	2 572	2 158	2 633	6.0	7.5
14-90 DJ.....	15	May 15	185.1	19 267	10.4	9	10 438	2 637	2 066	3 501	....	....
24 PC.....	16	May 23	174.6	16 473	9.4	6	9 210	2 245	1 117	3 098	10.2	10.2
39-90 PC.....	16	June 12	203.2	19 094	9.4	10	11 405	2 620	1 436	3 130	10.0	6.8
66 PC.....	16	July 2	196.4	15 436	7.9	7	8 641	1 741	1 681	2 631	7.6	9.7

¹Weight of both ovaries. ²Contained a cyst.

posited for chemical analysis. The data on the fetuses are arranged from left to right in the order in which they occurred, starting at the tip of the right horn of the uterus. The occurrence of partially absorbed or degenerated fetuses is indicated in the body of the table and their weights are recorded in the footnotes.

The data obtained from gilts examined in different stages of pregnancy, including weights of ovaries, have been summarized in Table 4. The uterus and contents just before parturition represent from 8 to 10 percent of the live weight of the gilt. In two nonpregnant gilts weighing 250 and 220 pounds the weights of the uteri were 222 grams and 207 grams respectively, representing .195 and .207 percent of the live weight.

The three gilts slaughtered at the end of 16 weeks of gestation gained 122, 121, and 117 pounds from the date of successful mating to the date of slaughter. The products of conception constitute, respectively, 29.8, 28.1, and 36.0 percent of the live weight gained during pregnancy. The first gilt was carrying 6 fetuses, the second 7, and the third 10.

The weights and lengths of fetuses as measured in this experiment are all greater than those for like ages reported by Warwick,^{13*} but whereas in Warwick's data the weight of the fetus first reaches that of the fetal membranes between the sixtieth and seventieth days of the gestation period, in the data given here that relation occurred between the seventieth and the seventy-seventh day of gestation.

A more detailed analysis of fetus weights is given in Table 5. The variability in fetus weights, as measured by the coefficient of variation,

TABLE 5.—AVERAGE WEIGHTS OF MALE AND FEMALE FETUSES AT DIFFERENT AGES, AND THEIR VARIABILITY

Gilt No.	Week of pregnancy	Number of normal fetuses	Average weights of—			Variability in weights of fetuses ¹
			Male fetuses	Female fetuses	All fetuses	
13 PC.....	5	9	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>perct.</i>
99 PC.....	6	7	.....	.....	4.46	18.8
26-39 DJ.....	7	10	16.57	14.73	15.78	10.2
67-90 PC.....	8	6	37.62	35.67	36.65	5.6
3-90 PC.....	9	7	83.09	82.96	83.05	6.9
24-90 PC.....	10	5	156.5	159.5	158.2	3.9
65-90 H.....	11	12	292	218	263	20.0
32 DJ.....	12	12	417	359	388	12.8
69-30 DJ.....	12	9	446	449	447	17.9
13-99 DJ.....	13	11	472	451	461	12.3
69-33 DJ.....	14	10	547	563	558	11.3
24-9 PC.....	14	7	1 043	1 041	1 042	8.6
14-90 DJ.....	15	9	1 082	1 005	1 049	5.2
24 PC.....	16	6	1 132	1 167	1 160	9.3
39-90 PC.....	16	10	1 597	1 504	1 535	4.7
66 PC.....	16	7	1 175	1 106	1 141	13.9
			1 286	1 195	1 234	10.7

¹These percentages are coefficients of variation, that is, standard deviations expressed as percentages of the corresponding means.

decreased rather regularly from 18.8 at 5 weeks of gestation to 3.9 at 9 weeks. Then followed a period of greatly increased variability, the coefficient being 20.0 at 10 weeks, and remaining above 10 for the following 4 weeks, after which smaller coefficients prevailed irregularly up to the end of gestation, at which time two larger coefficients of 13.9 and 10.7 were obtained. The biological significance, if any, of these changes in variability is not evident.

The male fetuses averaged heavier in weight than the female fetuses in 11 of the 15 litters in which sex was distinguished. The mean percentage difference between sex averages for these 15 litters with its probable error was 5.5 ± 1.4 . It may be said, therefore, with considerable assurance that, from the sixth to the sixteenth week of gestation at least, male pig fetuses tend to have a greater weight than female fetuses. Among a large number of unselected litters, exhibiting considerable heterogeneity, Carmichael and Rice^{1*} have reported only a small advantage in birth weight of male pigs over female pigs; i.e., 2.59 pounds compared with 2.51 pounds.

Concerning the effect of size of litter upon weights of fetuses, there are only three pertinent comparisons; namely, between the two or more gilts killed at the same stage of gestation at the end of the twelfth, fourteenth, and sixteenth weeks. At the twelfth and fourteenth weeks different-sized litters were obtained, but the average fetus weight, while favoring the smaller litter, was very nearly the same for litters of 12 and 9 and for litters of 10 and 7, respectively. At the sixteenth week the litter from Gilt 24 PC, numbering 6, was heavier per fetus than the other litters of the same age, out of all proportion to differences in size of litter. The difference in average fetus weight between litters from Gilts 39-90 PC and 66 PC favors the smaller litter.

Chemical Composition of Samples

The chemical composition of total fetuses and membranes and of the uteri, both when containing all the products of conception and after their removal, is given in Tables 6, 7, 8, and 9. The analyses of the fluids removed from the uterus are not in themselves of any significance, since variable amounts of blood contaminated the amniotic fluids. The results of these analyses, therefore, are not given, altho they have, of course, been used in computing the composition of the uteri plus contents.

In the fetus samples the rapid increase in dry matter with increasing age is simply an instance of a phenomenon of general occurrence in growing organisms. To remove the effects of this change upon the variations in the percentage occurrence of the other constituents, the

TABLE 6.—PERCENTAGE COMPOSITION OF FETUSES

Gilt No.	Week of pregnancy	Dry substance	Crude protein	Ether extract	Ash	Gross energy ¹	Total N	Fe	Ca	P
13 PC.....	5	8.90	6.14	.50	1.09	..	.98	.....	.026	....
99 PC.....	6	8.15	6.38	.52	1.33	453	1.02	.0024	.153	.192
26-39 DJ.....	7	10.00	6.75	.43	1.65	454	1.08	.0022	.257	.250
67-90 PC.....	8	10.02	6.50	.34	1.75	446	1.04	.0025	.284	.250
3-90 PC.....	9	9.88	6.11	.64	1.70	428	.98	.0017	.311	.276
24-90 PC.....	10	10.01	6.50	.77	1.75	467	1.04	.0012	.338	.234
65-90 H.....	11	10.35	7.38	.64	2.25	496	1.18	.0033	.540	.292
32 DJ.....	12	11.63	7.25	.76	2.54	547	1.16	.0029	.610	.346
69-30 DJ.....	12	11.59	7.44	.84	2.21	538	1.19	.0028	.500	....
13-99 DJ.....	13	12.09	7.69	.84	2.51	581	1.23	.0027	.596	.366
69-33 DJ.....	14	14.89	9.13	1.11	3.15	685	1.46	.0033	.777	.473
24-9 PC.....	14	14.50	8.81	1.11	3.22	675	1.41	.0026	.849	.447
14-90 DJ.....	15	17.53	10.38	1.13	3.71	767	1.66	.0022	1.055	.633
24 PC.....	16	16.81	10.63	1.07	3.51	802	1.70	.0038	.960	.523
39-90 PC.....	16	17.14	9.55	.91	3.47	750	1.53	.0026	1.005	.527
66 PC.....	16	17.21	10.11	.90	3.28	768	1.62	.0028	.885	.586

¹Expressed as small calories per gram.

TABLE 7.—PERCENTAGE COMPOSITION OF FETAL MEMBRANES

Gilt No.	Week of pregnancy	Dry substance	Crude protein	Ether extract	Ash	Gross energy ¹	Total N	Fe	Ca	P
13 PC.....	5	4.63	3.44	.50	.85	231	.55	.0017	.052	.080
99 PC.....	6	4.83	3.44	.27	1.03	223	.55	.0016	.089	.098
26-39 DJ.....	7	4.89	3.28	.43	.86	206	.53	.0018	.039	.063
67-90 PC.....	8	4.56	3.06	.32	.95	200	.49	.0022	.073	.064
3-90 PC.....	9	4.03	2.58	.36	.73	163	.41	.0017	.033	.065
24-90 PC.....	10	4.56	2.92	.27	.89	188	.47	.0015	.045	.063
65-90 H.....	11	5.23	3.51	.38	.85	259	.56	.0018	.059	.076
32 DJ.....	12	6.41	4.66	.43	.73	327	.75	.0030	.035	.069
69-30 DJ.....	12	5.86	4.44	.56	.78	305	.71	.0019	.015	.065
13-99 DJ.....	13	7.43	5.89	.65	.81	413	.94	.0030	.020	.075
69-33 DJ.....	14	6.93	4.92	.58	.82	356	.79	.0022	.013	.060
24-9 PC.....	14	7.29	5.28	.52	.93	373	.85	.0026	.057	.095
14-90 DJ.....	15	7.98	5.94	.43	.91	434	.95	.0035	.026	.077
24 PC.....	16	8.16	6.11	.35	1.11	398	.98	.0031	.102	.111
39-90 PC.....	16	6.88	5.69	.41	.87	382	.91	.0027	.065	.072
66 PC.....	16	9.11	7.06	.37	1.04	435	1.13	.0032	.069	.086

¹Expressed as small calories per gram.

TABLE 8.—PERCENTAGE COMPOSITION OF EMPTY UTERI

Gilt No.	Week of pregnancy	Dry substance	Crude protein	Ether extract	Ash	Gross energy ¹	Total N	Fe	Ca	P
13 PC.....	5	14.54	12.81	.39	.89	767	2.05	.0030	.007	.114
99 PC.....	6	12.52	11.56	.46	.93	684	1.85	.0028	.014	.093
26-39 DJ.....	7	13.85	11.88	.34	1.04	708	1.90	.0094	.012	.097
67-90 PC.....	8	14.47	12.69	.35	.74	758	2.03	.0033	.013	.095
3-90 PC.....	9	13.45	11.25	.64	.84	692	1.80	.0026	.012	.118
24-90 PC.....	10	14.27	13.06	.37	.89	777	2.09	.0036	.011	.093
65-90 H.....	11	13.84	11.94	.41	1.02	726	1.91	.0031	.013	.103
32 DJ.....	12	14.44	12.63	.46	1.00	760	2.02	.0048	.012	.098
69-30 DJ.....	12	13.68	12.25	.63	.90	726	1.96	.0028	.011	.096
13-99 DJ.....	13	13.24	12.38	.30	1.02	750	1.98	.0068	.009	.097
69-33 DJ.....	14	13.81	11.81	.50	.99	736	1.89	.0029	.017	.098
24-9 PC.....	14	13.75	12.31	.28	1.04	762	1.97	.0032	.008	.108
14-90 DJ.....	15	12.03	10.75	.39	1.08	672	1.72	.0048	.008	.094
24 PC.....	16	14.73	12.06	.43	1.06	750	1.93	.0084	.008	.118
39-90 PC.....	16	13.37	11.50	.56	.98	702	1.84	.0028	.009	.091
66 PC.....	16	14.23	12.19	.27	1.08	741	1.95	.0025	.009	.107

¹Expressed as small calories per gram.

TABLE 9.—PERCENTAGE COMPOSITION OF UTERI PLUS CONTENTS

Gilt No.	Week of pregnancy	Dry substance	Crude protein	Ether extract	Ash	Gross energy ¹	Total N	Fe	Ca	P
13 PC.....	5	7.04	5.92	.30	.63	353	.95	.0016	.022	.063
99 PC.....	6	8.33	7.28	.36	.90	440	1.16	.0022	.044	.086
26-39 DJ.....	7	7.64	5.99	.30	.90	365	.96	.0041	.044	.078
67-90 PC.....	8	7.30	5.79	.29	.82	356	.93	.0022	.063	.078
3-90 PC.....	9	5.20	3.78	.31	.69	237	.60	.0014	.054	.074
24-90 PC.....	10	7.86	6.18	.35	.98	389	.99	.0020	.084	.093
65-90 H.....	11	6.38	4.74	.31	1.05	311	.76	.0016	.050	.120
32 DJ.....	12	8.51	6.00	.44	1.37	412	.96	.0029	.240	.160
69-30 DJ.....	12	8.89	6.55	.59	1.29	433	1.05	.0025	.202	.240
13-99 DJ.....	13	10.13	7.30	.58	1.68	511	1.17	.0037	.312	.216
69-33 DJ.....	14	11.55	7.78	.75	2.01	553	1.24	.0030	.410	.270
24-9 PC.....	14	11.50	7.85	.70	2.05	562	1.26	.0028	.440	.260
14-90 DJ.....	15	13.22	8.96	.77	2.49	637	1.43	.0032	.600	.385
24 PC.....	16	14.23	9.66	.77	2.49	686	1.55	.0046	.583	.348
39-90 PC.....	16	14.01	8.89	.72	2.47	647	1.42	.0030	.626	.348
66 PC.....	16	14.48	9.64	.63	2.35	664	1.54	.0028	.532	.375

¹Expressed as small calories per gram.

TABLE 10.—PERCENTAGE COMPOSITION OF FETUSES ON THE DRY-MATTER BASIS

Gilt No.	Week of pregnancy	Crude protein	Ether extract	Ash	Gross energy per gram dry matter	Total nitrogen	Iron	Calcium	Phosphorus	Calcium in ash	Phosphorus in ash	Ca to P ratio
					<i>cal.</i>							
13 PC	5	69.0	5.62	12.2	11.0	11.0	.....	.29	.....	2.7	.....	.....
99 PC	6	78.3	6.38	16.3	5.56	12.5	.029	1.88	2.36	11.5	14.4	1 : 1.25
26-39 DJ	7	67.5	4.30	16.5	4.54	10.8	.022	2.57	2.50	15.6	15.2	1 : .97
67-90 PC	8	64.9	3.39	17.5	4.45	10.4	.025	2.83	2.49	16.2	14.3	1 : .88
3-90 PC	9	61.8	6.48	17.2	4.33	9.9	.017	3.15	2.79	18.3	16.2	1 : .89
24-90 PC	10	64.9	7.69	17.5	4.66	10.4	.012	3.38	2.34	19.3	13.4	1 : .69
65-90 H	11	71.3	6.18	21.7	4.79	11.4	.032	5.22	2.82	24.0	13.0	1 : .54
32 DJ	12	62.3	6.53	21.8	4.70	10.0	.025	5.24	2.97	24.0	13.6	1 : .57
69-36 DJ	12	64.2	7.25	19.1	4.64	10.3	.024	4.31	.....	22.6	.....	.....
18-99 DJ	13	63.6	6.95	20.8	4.80	10.2	.022	4.93	3.03	23.7	14.6	1 : .61
69-33 DJ	14	61.3	7.45	21.1	4.60	9.8	.022	5.22	3.18	24.7	15.0	1 : .61
24-9 PC	14	60.7	7.65	22.2	4.65	9.7	.018	5.85	3.08	26.4	13.9	1 : .53
14-90 DJ	15	59.2	6.45	21.2	4.37	9.5	.013	6.02	3.61	28.4	17.1	1 : .60
24 PC	16	63.2	6.36	20.9	4.77	10.1	.023	5.71	3.11	27.3	14.9	1 : .54
39-90 PC	16	55.7	5.31	20.2	4.37	8.9	.015	5.86	3.07	29.0	15.2	1 : .52
66 PC	16	58.7	5.23	19.0	4.46	9.4	.016	5.14	3.40	27.0	17.9	1 : .66

analytical results have been calculated to the dry-matter basis and summarized in Table 10. Certain interesting changes are evident from this table. The percentage of fat (ether extract), as well as the gross energy content per gram of dry matter, shows no progressive increase or decrease during the course of intrauterine life. The nitrogen and crude-protein content are also of this description, exhibiting only irregular variations, except possibly a decrease in the last few weeks of gestation. The ash content of the fetuses on the dry-matter basis increases from 12 to about 22 percent from the fifth to the eleventh week of gestation, with no further progressive change during the last five weeks of pregnancy. The percentages of calcium and of phosphorus increase irregularly up to the termination of pregnancy, as do also the percentages of calcium and, less certainly, of phosphorus in the ash. The ratio of calcium to phosphorus increases from a value of 1 to 1.25 at the sixth week, to more than 1 to .60 at the eleventh week, with no clearly progressive change evident from then to parturition. The iron content of the fetuses varied irregularly around an average value of .021 percent of the dry matter.

TABLE 11.—PERCENTAGE COMPOSITION OF FRESH FETAL LIVERS AND SPLEENS

	Dry matter	Crude protein	Ether extract	Ash	Gross energy ¹	Iron	Calcium	Phosphorus
Livers								
Gilt No. 39-90 PC....	22.85	9.81	1.35	1.17	1 147	.020	.0091	.211
Gilt No. 66 PC.....	21.98	11.19	1.06	1.55	1 146	.017	.0091	.251
Spleens								
Gilt No. 39-90 PC....	17.34	....	....	....	....	.014	....	....
Gilt No. 66 PC.....	18.08	....	....	....	....	.016	....	....

¹Expressed in small calories per gram.

For the purpose of determining to what extent iron was stored up in the fetal liver and the fetal spleen, the livers and spleens of the fetuses from two of the gilts carried to the end of the sixteenth week of pregnancy were removed for separate analyses. The blood draining from these organs after removal was added to the respective fetus sample. The weights of the fetal livers and spleens are given in Table 3. For each of the two litters a composite sample was made for each organ for chemical analysis, the results of which are given in Table 11. The composite spleen sample was so small that it was analyzed only for dry matter and iron.

The iron content of the fetal livers and spleen was considerably greater than that of the entire fetus (Table 6), indicating a storage of iron in these organs. But the fetal livers and spleens are not richer in iron than the corresponding organs from adult pigs, judging from the analyses reported by Elvehjem and Peterson.^{2*} According to their

analyses, hog liver, with a dry-matter content of 31.3 percent, contains an average of .025 percent of iron, or on the dry basis .080 percent. The fetal pig livers analyzed in this experiment contained an average of .018 percent of iron on the fresh basis, and .083 percent on the dry basis. Hog spleen, containing 22.1 percent of dry matter, analyzed .029 percent iron on the fresh basis and .133 percent on the dry basis. The fetal spleens of this experiment contained an average of .015 percent of iron on the fresh basis and .084 percent on the dry basis. From these comparative figures there is no evidence that the pig at birth is any better fortified against a régime on a low-iron diet than is the adult pig.

It is interesting to note with reference to the analyses of the fetal livers that the sum of the crude protein, ether extract, and ash percentages is considerably smaller than the percentage of dry substance. In one litter of fetuses the undetermined dry matter is equivalent to 46.0 percent of the total dry matter, while in the other litter it accounts for 37.2 percent. These figures suggest a high content of glycogen in fetal livers, but Mendel and Leavenworth^{10*} were unable to detect even traces of glycogen in the livers of pig fetuses as old as approximately 90 days. There is, of course, a possibility that in the last three weeks of intrauterine life glycogen accumulates in high concentration in the livers of pig fetuses. The low percentages of ether extract in these livers, 1.35 and 1.06, indicate that the pig, unlike the guinea pig, does not store any considerable amount of fat in the liver during intrauterine life. According to Imrie and Graham,^{6*} the guinea-pig fetus accumulates large amounts of fat in its liver during the latter part of intrauterine life, a storage which is rapidly depleted soon after birth.

Mathematical Analysis of Chemical Data

The primary purpose of this investigation was to measure the rate of deposition of nutrients in the uterus of the pregnant gilt thruout the period of fetal growth. The data actually obtained, however, by the chemical analysis of the uterus and contents of gilts sacrificed in groups of one to three at weekly intervals from the fifth to the sixteenth weeks of pregnancy, do not give directly any connected picture of fetal growth or of the growth of the total products of conception. The gaps in the picture are too large and the irregularities in the data too extreme to afford anything but a rough idea of the processes under study. Much more difficult would be the task of obtaining consistent and significant measures of the *rates* of growth with respect to different nutrients from the "raw" data as it came from the laboratory.

Obviously the occasion calls for a mathematical analysis of the

TABLE 12.--TOTAL WEIGHTS OF UTERI AND CONTENTS AND OF THE CHEMICAL CONSTITUENTS CONTAINED IN THEM
(All weights in grams)

Gilt No.	Week of pregnancy	Number of fetuses	Total fresh weight	Weight of--							Content of gross energy	
				Dry substance	Crude protein	Ether extract	Ash	Total nitrogen	Iron	Calcium		Phosphorus
13 PC.....	5	9	2 272	160	134	6.87	14.0	21.5	.036	.495	1.44	<i>cal.</i> 803
99 PC.....	6	7	2 596	216	189	9.45	23.3	30.2	.058	1.15	2.22	1 143
26-39 DJ.....	7	10	4 084	312	245	12.5	36.7	39.1	.168	1.81	3.20	1 492
67-90 PC.....	8	6	4 420	323	256	12.9	36.3	40.9	.097	2.78	3.43	1 576
3-90 PC.....	9	7	9 480	493	358	29.2	65.2	57.3	.136	5.12	7.07	2 244
24-90 PC.....	10	5	6 409	507	396	22.8	63.7	63.4	.129	5.67	6.10	2 500
65-90 H.....	11	12	19 856	1 267	942	61.0	208	151	.328	30.1	19.7	6 185
32 DJ.....	12	12	14 659	1 248	880	65.0	202	141	.420	35.4	23.2	6 039
69-30 DJ.....	12	9	10 678	950	700	63.1	138	112	.272	21.6	26.1	4 626
13-99 DJ.....	13	11	12 012	1 217	877	69.9	202	140	.445	37.5	26.0	6 139
69-33 DJ.....	14	10	20 295	2 345	1 579	153	407	253	.609	82.7	54.8	11 227
24-9 PC.....	14	7	14 639	1 683	1 149	103	301	184	.411	64.5	38.2	8 225
14-90 DJ.....	15	9	18 578	2 457	1 664	143	463	266	.591	111.4	71.5	11 845
24 PC.....	16	6	15 586	2 218	1 506	120	388	241	.717	90.8	54.2	10 693
39-90 PC.....	16	10	18 440	2 611	1 643	133	460	263	.544	116.9	65.0	11 987
66 PC.....	16	7	14 562	2 117	1 406	92	345	225	.408	79.4	55.4	9 707

data in order to fill in the gaps in the most satisfactory manner and to remove those irregularities in the data that result from random sampling and environmental disturbances rather than from inherent changes with age of the growth processes themselves.

The first step in this analysis was to compute, from the weight and composition of the various samples, the total contents of the uteri in the various chemical constituents. The results of this computation are given in Table 12.

Not all these weights of constituents, however, are products of conception, since they include the materials that would have been present in the nonpregnant uterus. Estimates must, therefore, be made of these constituents. In three nonpregnant gilts the weight of uterus was found to equal 88.8, 94.1, and 74.2 grams per 100 pounds body weight, with an average of 85.7 grams. Chemical analysis of these uteri gave the following average percentage composition: dry matter 21.94, crude protein 15.50, ether extract 5.36, ash 1.07, total nitrogen 2.48, iron .00201, calcium .0116, phosphorus .134, and gross energy 1,367 small calories per gram.

Furthermore, the number of normal fetuses found in the uteri of these gilts varied from 5 to 12, averaging 8.56, and much of the variation in weights of constituents among successive gilts was due to this fact. Hence it seems necessary to correct such weights to some standard litter size. All weights of constituents, after deduction of the estimated constituents in the nonpregnant uterus, were therefore corrected to a litter size of 8 by direct ratio. Thus in a litter of 6 all weights were increased by a third, and in a litter of 10 they were decreased by a fifth. It is admitted that this correction is only partially justifiable, but information does not seem to be at hand to make the correction on a more satisfactory basis. In particular, the weights of constituents in larger litters should not be reduced as much as the ratio of 8 to their litter number, since larger litters are associated with smaller fetus weights; and conversely, the weights from smaller litters should not be increased as much as they are by the method used. In the absence, however, of any definite knowledge of the regression of fetus weight on litter size at different stages of gestation no other method of correction seemed available.

It is not believed that the errors committed by this correction method are large. Thus from Table 3 it appears that for the two gilts sacrificed after 12 weeks of pregnancy, the average fetus weight for the litter of 9 was 461 grams, and for the litter of 12, almost as much, 447 grams. For the two gilts slaughtered after 14 weeks of pregnancy the average fetus weight for the litter of 7 was 1,049 grams, and for

the litter of 10 was 1,042 grams. For the three gilts killed after 16 weeks of pregnancy the average fetus weight was 1,535 grams for the litter of 6, 1,234 grams for the litter of 7, and 1,141 grams for the litter of 10. At birth, according to Carmichael and Rice,^{1*} there is no great difference between weights of pigs in large and in small litters. From a survey of 549 litters, averaging 8.1 pigs per litter, they found the average birth weight in all litters with fewer pigs than the average to be 2.67 pounds, and that with more pigs than the average, 2.47 pounds.

In Table 13 these corrections have been made with reference to fresh weight of the products of conception; weights of crude protein, ash, calcium, phosphorus, and iron; and calories of gross energy. These are the data of significance to the problem of the nutritive requirements for reproduction in swine.

Before attempting to describe these several groups of data by appropriate mathematical expressions, it is of interest to inquire what fraction of the nutrients contained in the total products of conception are found in the fetuses themselves at different stages of gestation. This information is given in Table 14. The percentages with respect to each of the constituents increase with the progress of gestation, but this increase is much faster with respect to some constituents than with respect to others. For ash, calcium, and phosphorus the fetuses account for 85 to 95 or more percent of the total at parturition, and for more than 70 percent of the dry matter and the gross energy. In fresh weight and in iron, however, the fetuses, even at parturition, account for only slightly more than half the total, due to the presence of the amniotic fluids in the uterus and evidently to the fact that a disproportionate share of the blood was present in the nonfetal parts.

The mathematical equation fitted to the data of Table 13 is one that has been successfully used in describing intrauterine growth in a number of species of animals;^{8, 11, 12*} namely, $W = kt^n$, W being, in this case, the weight of the nutrient deposited in the uterus at the end of gestation week t , while k and n are constants to be determined from each set of data. The constants were determined by the method of least squares. The resulting equations are as follows:

- (a) Total fresh weight of products of conception: $W = 99.05t^{1.886}$
- (b) Total gross energy: $W = 4.077t^{2.841}$
- (c) Total crude protein: $W = 1.523t^{2.482}$
- (d) Total ash: $W = .06166t^{3.176}$
- (e) Calcium: $W = .0001940t^{4.748}$
- (f) Phosphorus: $W = .002167t^{3.690}$
- (h) Iron: $W = .8174t^{2.368}$

In the case of iron, W is the weight in milligrams rather than in grams.

TABLE 13.—NUTRIENTS IN UTERUS OF SOWS ABOVE THOSE IN NONPREGNANT UTERUS, CORRECTED TO LITTER OF EIGHT

Gilt No.	Week of pregnancy	Size of litter	Total fresh weight	Crude protein	Total ash	Calcium	Phosphorus	Iron	Gross energy
			<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>mgms.</i>	<i>cal.</i>
13 PC.....	5	9	1 768	80	9.8	.41	.94	27	370
99 PC.....	6	7	2 571	154	22.4	1.27	2.01	58	765
26-39 DJ.....	7	10	3 085	167	27.4	1.43	2.32	130	944
67-90 PC.....	8	6	5 547	288	44.7	3.67	4.11	123	1 628
3-90 PC.....	9	7	10 538	363	71.4	5.82	7.68	150	2 159
24-90 PC.....	10	5	9 776	560	97	8.51	9.12	197	3 346
65-90 H.....	11	12	13 004	592	136	20.0	12.8	214	3 805
32 DJ.....	12	12	9 531	549	132	23.6	15.1	275	3 696
69-30 DJ.....	12	9	9 164	571	119	19.2	22.8	236	3 664
13-99 DJ.....	13	11	8 526	605	145	27.2	18.6	319	4 178
69-33 DJ.....	14	10	15 970	1 222	322	66.1	43.5	482	8 618
24-9 PC.....	14	7	16 369	1 257	341	73.6	43.1	463	8 904
14-90 DJ.....	15	9	16 235	1 436	409	98.9	63.2	520	10 148
24 PC.....	16	6	20 381	1 947	513	121.1	71.7	948	13 710
39-90 PC.....	16	10	14 473	1 271	365	93.5	51.7	430	9 208
66 PC.....	16	7	16 252	1 546	390	90.6	62.8	458	10 559

TABLE 14.—CONSTITUENTS OF FETUSES IN PERCENTAGE OF CONSTITUENTS IN TOTAL PRODUCTS OF CONCEPTION

Gilt No.	Week of pregnancy	Fresh substance	Dry matter	Crude protein	Ether extract	Ash	Gross energy	Iron	Calcium	Phosphorus
13 PC.....	5	2	3.6	2.7	..	4	3.8	..	2.4	..
99 PC.....	6	5	6	5	..	7	7	6	15	12
26-39 DJ.....	7	9	14	12	..	17	14	5	52	31
67-90 PC.....	8	12	18	15	..	26	18	13	51	40
3-90 PC.....	9	12	25	21	46	30	25	14	67	45
24-90 PC.....	10	21	30	24	..	38	29	13	79	54
65-90 H.....	11	24	40	39	71	51	40	48	84	66
32 DJ.....	12	38	53	47	89	69	53	37	92	82
69-30 DJ.....	12	40	55	48	81	68	54	44	96	88
13-99 DJ.....	13	52	64	56	94	77	62	39	97	87
69-33 DJ.....	14	52	68	62	85	81	66	57	98	90
24-9 PC.....	14	51	66	58	95	79	63	47	96	87
14-90 DJ.....	15	57	76	67	93	84	70	39	99	93
24 PC.....	16	60	72	67	95	84	80	49	97	89
39-90 PC.....	16	63	77	68	91	87	74	56	98	93
66 PC.....	16	61	73	65	..	83	72	58	96	92

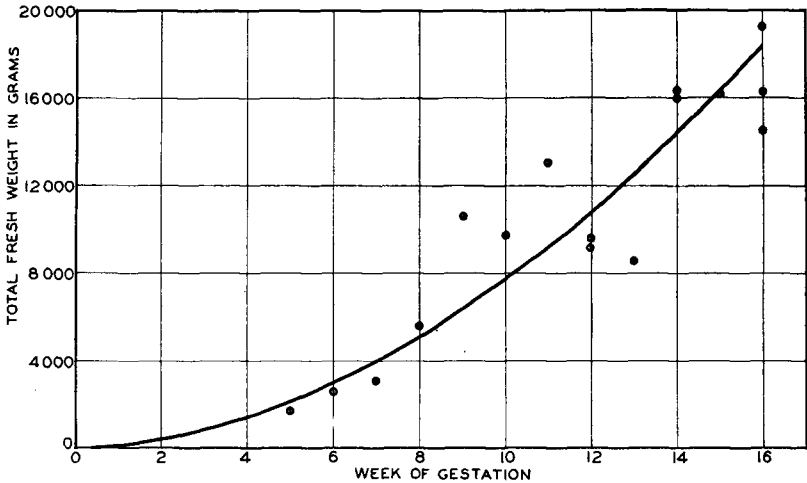


FIG. 1.—FRESH WEIGHT OF TOTAL PRODUCTS OF CONCEPTION AT DIFFERENT STAGES OF GESTATION

The fit of these equations to their respective sets of data is shown in Figs. 1 to 7. The total products of conception, fresh weight, showed such a variable and irregular increase that no simple mathe-

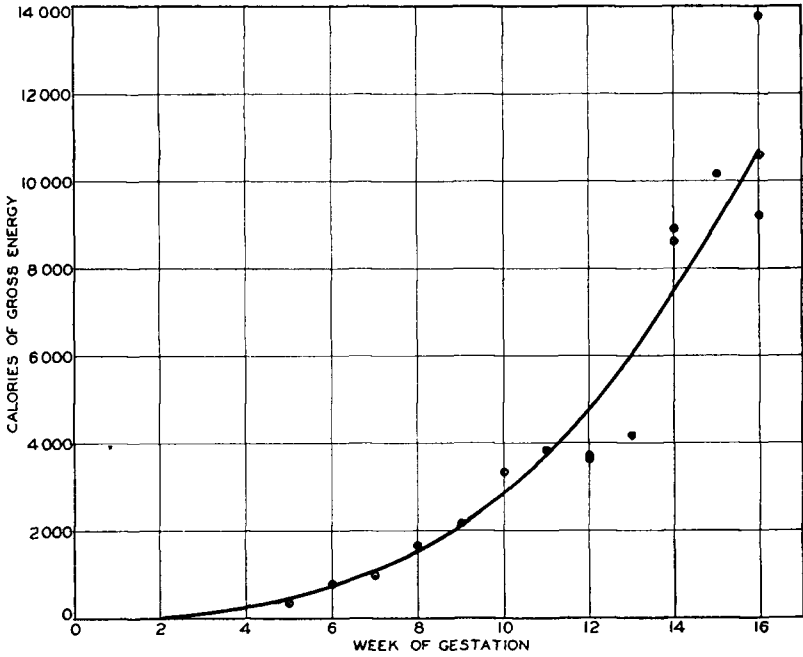


FIG. 3.—GROSS ENERGY CONTENT OF MATERIAL DEPOSITED AT DIFFERENT STAGES OF GESTATION

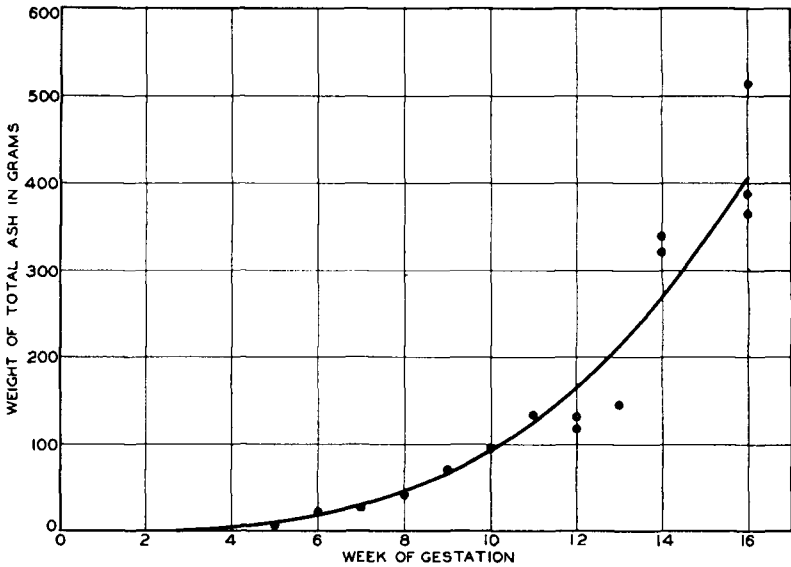


FIG. 4.—DEPOSITION OF TOTAL ASH AT DIFFERENT STAGES OF GESTATION

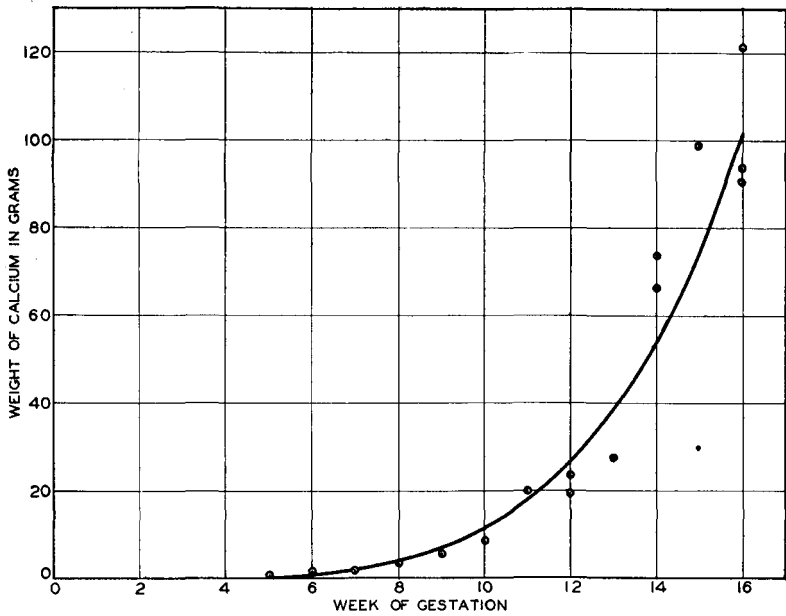


FIG. 5.—DEPOSITION OF TOTAL CALCIUM AT DIFFERENT STAGES OF GESTATION

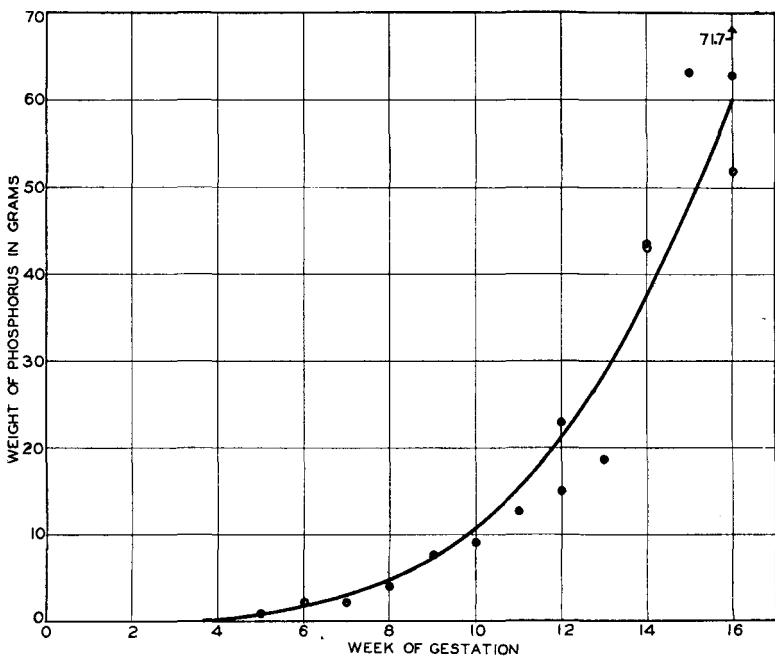


FIG. 6.—DEPOSITION OF TOTAL PHOSPHORUS AT DIFFERENT STAGES OF GESTATION

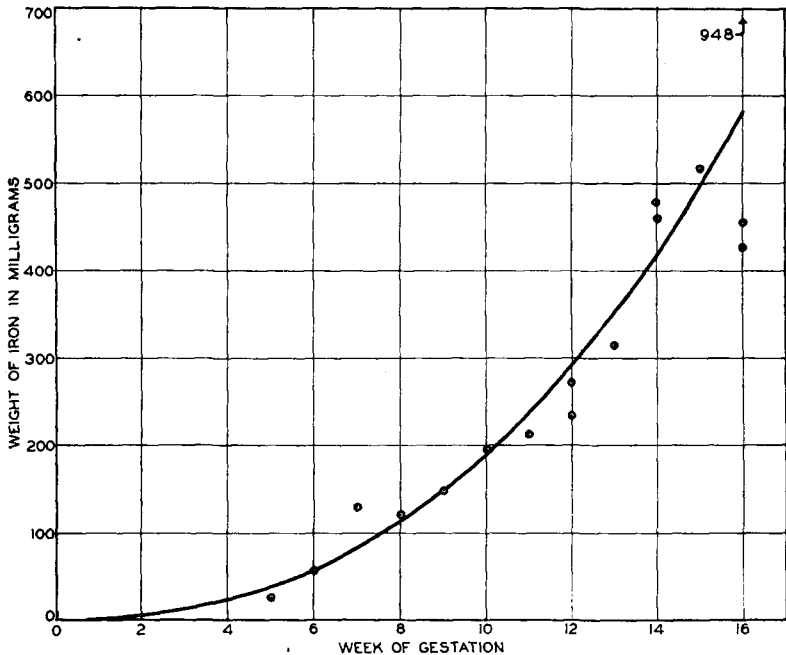


FIG. 7.—DEPOSITION OF TOTAL IRON AT DIFFERENT STAGES OF GESTATION

the deviations from points above the curve. For the other sets of data the agreement between the curves and the observations is much better, particularly up to and including the data for the eleventh week of gestation. Beyond this point considerable irregularity exists with all sets of data, but in all cases the curves pass thru the data as centrally as a simple curve can.

TABLE 15.—COMPUTED WEIGHTS, ENERGY CONTENTS, AND COMPOSITION OF THE TOTAL PRODUCTS OF CONCEPTION FOR A LITTER OF EIGHT

Week of gestation	Total fresh weight	Crude protein	Gross energy	Ash	Calcium	Phosphorus	Iron
	<i>gms.</i>	<i>gms.</i>	<i>cals.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>mgms.</i>
1.....	99	1.5	4.1	.06	.0002	.002	.82
2.....	366	8.5	29	.6	.005	.028	4.2
3.....	787	23	92	2	.036	.12	11
4.....	1 354	47	209	5	.14	.36	22
5.....	2 062	83	394	10	.40	.82	37
6.....	2 909	130	662	18	.96	1.61	57
7.....	3 891	191	1 026	30	2.0	2.8	82
8.....	5 005	265	1 499	45	3.8	4.7	113
9.....	6 251	356	2 094	66	6.6	7.2	149
10.....	7 625	462	2 825	92	10.9	10.6	191
11.....	9 127	585	3 703	125	17.1	15.1	239
12.....	10 755	726	4 742	165	26	21	294
13.....	12 507	886	5 952	213	38	28	355
14.....	14 385	1 065	7 347	269	54	37	423
15.....	16 384	1 263	8 938	335	74	47	499
16.....	18 505	1 483	10 736	411	101	60	581

From the fitted equations values for the weights of the various constituents deposited in the uterus at any stage of gestation may be computed. Such values for weekly intervals are contained in Table 15. These "smoothed" data may be considered more significant than the "raw" data contained in Table 13. Certainly they present a more plausible and consistent picture of the deposition of nutrients in the pregnant uterus, since each individual value is determined by the general trend of the data for all gilts examined rather than by the data obtained from one, two, or three gilts, any one of which may be affected to a considerable extent by a number of conditions with reference to individual behavior not representative of the particular stage of gestation at which they were sacrificed.

Another important advantage of a concise description of these data by means of mathematical equations, is that the rate of deposition of the nutrients in the uterus may be readily obtained by differentiation of the equations and solution for any desired value of t . Differentiation of the equation $W = kt^n$, yields the equation $\frac{dW}{dt} = nkt^{n-1}$

in which $\frac{dW}{dt}$ is the instantaneous rate at which the nutrient in question, W , is being deposited at any week of gestation, t , expressed, in these cases, in grams, milligrams, or calories per week. The differential equations obtained for the fresh weight of the products of conception and for the various nutrients, expressed for convenience in the logarithmic form, are as follows:

(a) Total fresh weight of products of conception: $\log\left(\frac{dW}{dt}\right) = 2.27150 + .88637 \log t$

(b) Total gross energy: $\log\left(\frac{dW}{dt}\right) = 1.06368 + 1.84066 \log t$

(c) Total crude protein: $\log\left(\frac{dW}{dt}\right) = .57760 + 1.48171 \log t$

(d) Total ash: $\log\left(\frac{dW}{dt}\right) = -.70811 + 2.17588 \log t$

(e) Calcium: $\log\left(\frac{dW}{dt}\right) = -3.03558 + 3.74793 \log t$

(f) Phosphorus: $\log\left(\frac{dW}{dt}\right) = -2.09712 + 2.69047 \log t$

(h) Iron: $\log\left(\frac{dW}{dt}\right) = .28689 + 1.36831 \log t$

TABLE 16.—COMPUTED DAILY RATE OF INCREASE IN WEIGHT AND ENERGY CONTENT, AND COMPUTED DAILY DEPOSITION OF NUTRIENTS IN THE UTERI OF PREGNANT GILTS

Week of gestation	Total weight	Crude protein	Gross energy	Ash	Calcium	Phosphorus	Iron
	<i>gms.</i>	<i>gms.</i>	<i>cal.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>mgms.</i>
1.....	27	.54	1.6	.028	.0001	.0011	.28
2.....	49	1.5	5.9	.126	.0018	.0074	.71
3.....	71	2.7	12.5	.30	.0081	.022	1.24
4.....	91	4.2	21	.57	.024	.048	1.84
5.....	111	5.9	32	.93	.055	.087	2.50
6.....	131	7.7	45	1.38	.109	.142	3.2
7.....	150	9.6	59	1.93	.194	.215	4.0
8.....	169	11.8	76	2.6	.32	.31	4.8
9.....	187	14	94	3.3	.50	.42	5.6
10.....	205	16	115	4.3	.74	.56	6.5
11.....	224	19	137	5.2	1.05	.72	7.4
12.....	242	21	160	6.2	1.46	.91	8.3
13.....	259	24	186	7.4	1.97	1.13	9.2
14.....	277	27	213	8.7	2.60	1.38	10.2
15.....	294	30	242	10.1	3.37	1.67	11.2
16.....	312	33	272	11.7	4.29	1.98	12.3

By solving for any value of t , the time in weeks from conception, the corresponding rates of deposition of the materials may be obtained. In Table 16 will be found the results of such calculations for the end of successive weeks of gestation, expressed in grams, milligrams, or calories per day rather than week. Thus at the end of the sixteenth week of gestation a pregnant gilt carrying an average litter of 8 is depositing in the uterus daily 312 grams of fresh material having an energy content of 272 calories and containing 33 grams of crude protein, 11.7 grams of ash constituents, 4.29 grams of calcium, 1.98 grams of phosphorus, and 12.3 milligrams of iron. At the termination of the

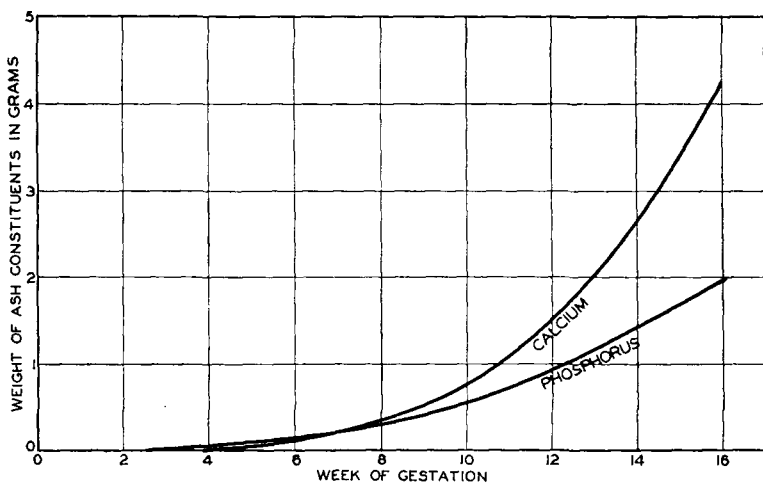


FIG. 8.—DAILY RATE OF DEPOSITION OF CALCIUM AND OF PHOSPHORUS AT DIFFERENT STAGES OF GESTATION

tenth week of gestation the rates of deposition of the various nutrients are one-half or less the rates just specified.

The rapid increase in the rate of deposition of calcium is particularly noteworthy. In the last three weeks of gestation the daily increase of calcium more than doubles. The rate of deposition of phosphorus also increases rapidly, but not nearly so rapidly as that of calcium. Fig. 8 compares the rates of deposition of these two elements for the entire sixteen weeks of gestation.

These rates of deposition measure the minimum daily requirements of the nutrients for reproduction. They are the final calculations towards which all the chemical work was directed; hence they are considered to be the most significant results of the entire investigation.

Nitrogen, Calcium, and Phosphorus Balances of Pregnant Gilts

Five of the pregnant gilts serving as subjects in this experiment were confined continuously in metabolism crates in the nutrition laboratory until the time of slaughter. Except for occasional short intervals of time, generally no more than two or three days, continuous balances of nitrogen, calcium, and phosphorus were obtained for these gilts in consecutive 10-day collection periods. For four of the gilts one or more collection periods were undertaken before the date of successful breeding. The balance sheets for all periods, containing the detailed data for intake, excretion, and storage of these elements, are given in Table 17. The balances of these elements only have been summarized for chronological comparison in Table 18.

A noteworthy feature of these nutritive balances as gestation progressed is that there is no tendency for an increase in storage, altho the demands of fetal growth are increasing, particularly in the last few weeks. In fact, with respect to phosphorus, there is a distinct tendency for the balances to decrease during the first half of the gestation period. Evans^{3*} also has noted no correspondence in the nutritive balances of nitrogen, phosphorus, and calcium and the demands for fetal growth in pregnant sows.

The average daily retentions of nitrogen, calcium, and phosphorus for each of the five gilts are given in Table 19. Thruout pregnancy there was an average daily storage of 7.12 grams of nitrogen, 4.38 grams of calcium, and 1.32 grams of phosphorus, representing 17.8, 31.5, and 16.0 percent, respectively, of the daily intakes of these elements. On a much more liberal régime of feeding Evans^{3*} secured with sows of considerably greater weight average daily balances of 12.51 grams of nitrogen, 4.58 grams of calcium, and 2.75 grams of phosphorus during pregnancy.

It is of interest to compare the total amounts of nitrogen, calcium, and phosphorus retained thruout the pregnancies of these gilts with the amounts deposited in the uterus. The former amounts were computed from the metabolism data, due allowance being made for the intermittent short periods of time for which collections were not made; the latter amounts were determined by actual analysis of the uterus and contents of each gilt, allowance being made for the nutrients con-

TABLE 17.—BALANCE DATA OF PREGNANT GILTS
(Results expressed on the daily basis)

Inclusive dates of metabolism periods	Nitrogen	Calcium	Phosphorus	Body weight at start of period
Gilt 39-90 PC, bred February 21, 1928				
	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>lbs.</i>
January 19 to 25.....	Intake..... 47.63 Output..... 32.80 Balance..... +14.83	16.55 8.15 +8.40	9.80 6.19 +3.61	298
January 26 to 31.....	Intake..... 47.63 Output..... 37.11 Balance..... +10.52	16.55 9.52 +7.03	9.80 7.96 +1.84	303
February 23 to 29.....	Intake..... 39.69 Output..... 30.57 Balance..... +9.12	13.79 7.08 +6.71	8.16 5.41 +2.75	331
March 1 to 10.....	Intake..... 39.69 Output..... 33.54 Balance..... +6.15	13.79 9.51 +4.28	8.16 7.55 +.61	340
March 14 to 23.....	Intake..... 39.69 Output..... 32.78 Balance..... +6.91	13.79 10.48 +3.31	8.16 7.69 +.47	355
March 24 to April 2.....	Intake..... 39.69 Output..... 32.97 Balance..... +6.72	13.79 9.66 +4.13	8.16 6.62 +1.54	365
April 3 to 12.....	Intake..... 39.69 Output..... 37.91 Balance..... +1.78	13.79 10.74 +3.05	8.16 7.06 +1.10	376
April 13 to 22.....	Intake..... 39.69 Output..... 33.21 Balance..... +6.48	13.79 10.34 +3.45	8.16 7.39 +.77	387
April 27 to May 6.....	Intake..... 39.69 Output..... 29.67 Balance..... +10.02	13.79 8.56 +5.23	8.16 5.66 +2.50	409
May 7 to 16.....	Intake..... 39.69 Output..... 31.94 Balance..... +7.75	13.79 9.82 +3.97	8.16 5.42 +2.74	418
May 17 to 26.....	Intake..... 39.69 Output..... 34.18 Balance..... +5.51	13.79 10.35 +3.44	8.16 6.96 +1.20	422
May 27 to June 5.....	Intake..... 39.69 Output..... 34.40 Balance..... +5.29	13.79 8.07 +5.72	8.16 6.69 +1.47	432
June 6 to 11.....	Intake..... 39.69 Output..... 34.98 Balance..... +4.71	13.79 10.54 +3.25	8.16 8.51 -.35	445

Note.—The line between the second and third periods indicates the location of the breeding date.

(This table is continued over the next four pages.)

tained in the nonpregnant uterus. The results of such calculations are summarized in Table 20.

For all gilts the storage of nitrogen, calcium, and phosphorus during pregnancy was greatly in excess of the amounts of nutrients actually used in fetal growth. On the average, only 31 percent of the nitrogen stored in the bodies of these gilts during pregnancy was used for the growth of the fetus, its membranes and fluids, and for the hypertrophy of the uterus; only 20 percent of the calcium stored was

TABLE 17.—Continued

Inclusive dates of metabolism periods	Nitrogen	Calcium	Phosphorus	Body weight at start of period
Gilt 24 PC, bred February 1, 1928				
	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>lbs.</i>
January 16 to 22.....	Intake..... 47.63 Output..... 33.19 Balance..... +14.44	16.55 8.57 +7.98	9.80 5.91 +3.89	251
January 23 to 29.....	Intake..... 47.63 Output..... 34.01 Balance..... +13.62	16.55 9.07 +7.48	9.80 6.65 +3.15	259
February 11 to 17.....	Intake..... 47.63 Output..... 34.68 Balance..... +12.95	16.55 8.73 +7.82	9.80 6.80 +3.00	278
February 21 to 27.....	Intake..... 39.69 Output..... 28.79 Balance..... +10.90	13.79 8.29 +5.50	8.16 5.77 +2.39	291
February 28 to March 5...	Intake..... 39.69 Output..... 36.82 Balance..... +2.87	13.79 12.93 +.86	8.16 8.98 -.82	302
March 6 to 15.....	Intake..... 39.69 Output..... 31.32 Balance..... +8.37	13.79 9.81 +3.98	8.16 7.55 +.61	310
March 16 to 25.....	Intake..... 39.69 Output..... 33.59 Balance..... +6.10	13.79 10.05 +3.74	8.16 7.00 +1.16	319
March 26 to April 4.....	Intake..... 39.69 Output..... 34.36 Balance..... +5.33	13.79 11.44 +2.35	8.16 7.13 +1.03	326
April 5 to 14.....	Intake..... 39.69 Output..... 33.46 Balance..... +6.23	13.79 10.96 +2.83	8.16 8.22 -.06	...
April 15 to 24.....	Intake..... 39.69 Output..... 30.17 Balance..... +9.52	13.79 10.80 +2.99	8.16 7.17 +.99	351
April 27 to May 6.....	Intake..... 39.69 Output..... 29.67 Balance..... +10.02	13.79 9.21 +4.58	8.16 6.17 +1.99	369
May 7 to 16.....	Intake..... 39.69 Output..... 34.44 Balance..... +5.25	13.79 9.38 +4.41	8.16 6.21 +1.95	375
May 17 to 22.....	Intake..... 39.69 Output..... 29.56 Balance..... +10.13	13.79 9.81 +3.98	8.16 6.68 +1.48	383

Note.—The line between the second and third periods indicates the location of the breeding date.

so used, and 40 percent of the phosphorus. These gilts were still growing at a rate sufficiently rapid to require 69 percent of all the nitrogen stored, 80 percent of all the calcium stored, and 60 percent of all the phosphorus stored.

TABLE 17.—Continued

dates of metabolism periods	Nitrogen	Calcium	Phosphorus	Body weight at start of period
Gilt 66 PC, bred March 12, 1928				
	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>lbs.</i>
.....	Intake..... 47.63	16.55	9.80	266
	Output..... 35.57	7.62	5.73	
	Balance..... +12.06	+8.93	+4.07	
.....	Intake..... 39.69	13.79	8.16	319
	Output..... 34.39	8.70	6.74	
	Balance..... +5.30	+5.09	+1.42	
.....	Intake..... 39.69	13.79	8.16	327
	Output..... 35.04	11.25	7.81	
	Balance..... +4.65	+2.54	+3.35	
.....	Intake..... 39.69	13.79	8.16	337
	Output..... 33.21	10.71	8.12	
	Balance..... +6.48	+3.08	+0.04	
.....	Intake..... 39.69	13.79	8.16	350
	Output..... 33.96	10.64	7.53	
	Balance..... +5.73	+3.14	+0.63	
.....	Intake..... 39.69	13.79	8.16	360
	Output..... 33.29	11.27	7.19	
	Balance..... +6.40	+2.52	+0.97	
.....	Intake..... 39.69	13.79	8.16	372
	Output..... 30.99	10.09	6.41	
	Balance..... +8.70	+3.70	+1.75	
.....	Intake..... 39.69	13.79	8.16	386
	Output..... 34.65	11.14	7.65	
	Balance..... +5.04	+2.65	+0.51	
.....	Intake..... 39.69	13.79	8.16	397
June 5.....	Output..... 34.64	10.13	7.92	
	Balance..... +5.05	+3.66	+0.24	
.....	Intake..... 39.69	13.79	8.16	409
	Output..... 32.42	6.61	.....
	Balance..... +7.27	+7.18	.....
.....	Intake..... 39.69	13.79	8.16	414
	Output..... 27.76	6.34	5.66	
	Balance..... +11.93	+7.45	+2.50	
.....	Intake..... 39.69	13.79	8.16	431
	Output..... 27.80	7.67	5.86	
	Balance..... +11.89	+6.12	+2.30	

..... and second periods indicates the location of breeding date

TABLE 17.—Continued

Inclusive dates of metabolism periods	Nitrogen	Calcium	Phosphorus	Body weight at start of period
Gilt 69-33 DJ, bred January 30, 1928				
	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	
January 17 to 23.....	Intake..... 47.63 Output..... 31.42 Balance..... +16.21	16.55 6.15 +10.40	9.80 5.14 +4.66	
January 24 to 29.....	Intake..... 47.63 Output..... 38.80 Balance..... +8.83	16.55 8.65 +7.90	9.80 6.93 +2.87	
February 3 to 9.....	Intake..... 47.63 Output..... 36.02 Balance..... +11.61	16.55 8.94 +7.51	9.80 6.58 +3.22	
February 20 to 26.....	Intake..... 39.69 Output..... 31.81 Balance..... +7.88	13.79 7.12 +6.67	8.16 5.55 +2.61	
February 27 to March 4.....	Intake..... 39.69 Output..... 29.55 Balance..... +10.14	13.79 6.87 +6.92	8. 5. +2.	
March 5 to 14.....	Intake..... 39.69 Output..... 33.73 Balance..... +5.96	13.79 9.47 +4.32	8. 8. —	
March 15 to 24.....	Intake..... 39.69 Output..... 32.67 Balance..... +7.02	13.79 8.71 +5.08	8. 6.7 +1.3	
March 25 to April 3.....	Intake..... 39.69 Output..... 33.49 Balance..... +6.20	13.79 9.71 +4.08	8.16 6.95 +1.21	
April 4 to 13.....	Intake..... 39.69 Output..... 32.31 Balance..... +7.38	13.79 8.78 +5.01	8.16 6.38 +1.78	
April 14 to 23.....	Intake..... 39.69 Output..... 32.96 Balance..... +6.73	13.79 9.20 +4.59	8.16 6.93 +1.23	
April 27 to May 6.....	Intake..... 39.69 Output..... 33.24 Balance..... +6.45	13.79 9.54 +4.25	8.16 7.14 +1.02	

Note.—The line between the second and third periods indicates the location of

TABLE 19.—AVERAGE DAILY RETENTION OF NITROGEN, CALCIUM, AND PHOSPHORUS DURING GESTATION

Gilt No.	Absolute retention			Percentage ¹ retention		
	Nitrogen	Calcium	Phosphorus	Nitrogen	Calcium	Phosphorus
	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>			
39-90 PC.....	6.40	4.23	1.34	16.1	30.7	16.4
24 PC.....	7.97	3.91	1.25	19.7	27.8	15.0
66 PC.....	7.13	4.28	1.07	18.0	31.0	13.1
69-33 DJ.....	7.71	5.38	1.69	19.0	38.2	20.3
14-90 DJ.....	6.38	4.08	1.25	16.1	29.6	15.3
Average.....	7.12	4.38	1.32	17.8	31.5	16.0

¹Computed on the intake.

TABLE 20.—COMPARISON OF TOTAL AMOUNTS OF NITROGEN, CALCIUM, AND PHOSPHORUS RETAINED DURING PREGNANCY WITH AMOUNTS DEPOSITED IN UTERUS

Gilt No.	Number of weeks of pregnancy		Nitrogen	Calcium	Phosphorus
69-33 DJ.....	14	Total retained, grams.....	768	535	172
		In uterus, grams.....	245	83	54
		Percent in uterus.....	32	16	31
14-90 DJ.....	15	Total retained, grams.....	724	463	153
		In uterus, grams.....	258	111	71
		Percent in uterus.....	36	24	46
24 PC.....	16	Total retained, grams.....	941	478	159
		In uterus, grams.....	234	91	54
		Percent in uterus.....	25	19	34
39-90 PC.....	16	Total retained, grams.....	729	474	155
		In uterus, grams.....	254	117	65
		Percent in uterus.....	35	25	42
66 PC.....	16	Total retained, grams.....	768	470	118
		In uterus, grams.....	216	79	55
		Percent in uterus.....	28	17	47
Average percentages of balances retained in uterus.....			31	20	40

SUMMARY

For the purpose of determining the minimum nutritive requirements for reproduction in swine, as measured by the rates of deposition of nutrients in the uterus, sixteen pregnant gilts were slaughtered at different stages of pregnancy, starting at the end of the fifth week, and the uteri and contents weighed, dissected, and subjected to chemical analysis. Five of the gilts were confined in metabolism crates for 14 to 16 weeks of pregnancy and their balances of nitrogen, calcium, and phosphorus were determined in consecutive 10-day periods.

All gilts were bred to the same boar of the Poland China breed, and they were all fed the same ration in amounts to produce an average daily gain of 1 to 1.25 pounds. While the gilts fed in one lot at the swine barn required an average daily intake of 8 pounds of feed, those confined in metabolism crates in the nutrition laboratory required only 5 pounds of feed daily. The much greater economy of gains in these

latter gilts than in the group-fed gilts must have been the result of close confinement, with correspondingly less activity, and possibly to some extent the result of a higher environmental temperature.

The digestibility of the ration and its content of metabolizable energy were determined, using the 5 gilts confined to metabolism crates. An average of 77.4 percent of the gross energy of the ration was found to be metabolizable.

For the three gilts slaughtered just previous to the time of normal parturition, that is, after 16 weeks of gestation, the total products of conception in the uterus accounted for 29.8, 28.1, and 36.0 percent of the live weight gained during pregnancy. The first gilt was carrying 6 fetuses, the second 7, and the third 10.

The variability in fetus weights within the same litter, as measured by the coefficient of variation, decreased rather regularly from 18.8 at 5 weeks of gestation to 3.9 at 9 weeks. Then followed a period of greatly increased variability, the coefficient being 20 at 10 weeks, and remaining above 10 for the following 4 weeks, after which smaller coefficients prevailed irregularly up to the end of gestation, at which time two larger coefficients of 13.9 and 10.7 were obtained.

The male fetuses averaged heavier in weight than the female fetuses in 11 of the 15 litters in which sex was determined. The mean percentage difference between sex averages for these 15 litters was 5.5 ± 1.4 . It may be said, therefore, with considerable assurance that, from the sixth to the sixteenth weeks of gestation at least, male pig fetuses tend to have a greater weight than female fetuses.

The chemical analysis of the fetus samples showed a progressively increasing percentage of dry matter as fetal age increased. On the dry-matter basis certain interesting changes in the composition of the fetuses were noted, particularly with reference to the total ash, calcium, and phosphorus. Neither the percentage of fat nor of iron showed any progressive variation with advancing pregnancy.

Altho the iron content of the livers and spleens taken from fetuses close to term was greater than that of the entire fetuses, indicating a storage of iron in these organs, it was not greater than published analyses of the iron content of livers and spleens from adult pigs.

For the purpose of a more thoro and complete description and interpretation, the chemical data with reference to the amounts of nutrients contained in the total products of conception at succeeding stages of gestation were, after correction to a uniform litter size of eight, fitted to the mathematical equation $W = kt^n$, in which W is the weight of a given constituent deposited at time t in the uterus.

From these fitted equations values for the weights of the various

constituents deposited in the uterus at any stage of gestation may be computed. Such computed values for weekly intervals are summarized in Table 15. These "smoothed data" may be considered more significant than the "raw" data as actually determined. Certainly they present a more plausible and consistent chemical picture of the course of pregnancy.

By the differentiation of these equations other equations may be obtained of the type $\frac{dW}{dt} = nkt^n - 1$, from which the rate of deposition

of the nutrients, $\frac{dW}{dt}$, may be computed for any time t . By solving these equations for any value of t , the time in weeks from conception, the corresponding rates of deposition may be obtained. The results of such calculations for the ends of successive weeks of gestation, expressed in grams, milligrams, or calories per day are given in Table 16.

At the termination of the sixteenth week of pregnancy a pregnant gilt carrying an average litter of eight may be expected to deposit in the uterus daily 312 grams of fresh material, having a gross energy content of 272 calories and containing 33 grams of crude protein, 11.7 grams of ash constituents, 4.29 grams of calcium, 1.98 grams of phosphorus, and 12.3 milligrams of iron. At the termination of the tenth week of gestation the rates of deposition of the various nutrients are only one-half or less of the rates just cited.

These rates of deposition of nutrients measure the minimum daily requirements of the nutrients for reproduction. They are the final calculations towards which all the chemical work was directed, and hence they are considered to be the most significant results of the entire investigation.

From the results of the balance experiments on five of the sixteen gilts it appeared that the gilts were storing nutritive material in their bodies at a much faster rate than they were depositing such material in the uterus, because they were themselves growing. The average daily retentions of nitrogen, calcium, and phosphorus thruout gestation were, respectively, 7.12, 4.38, and 1.32 grams, representing 17.8, 31.5 and 16.0 percent of the intakes of the respective nutrients. However, only 31 percent of the nitrogen stored, 20 percent of the calcium stored, and 40 percent of the phosphorus stored was used in the processes of reproduction, the remainder providing material for the growth of the gilts themselves. No tendency was evident for the retention of nutrients in the body to increase as pregnancy progressed.

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